

With stricter energy requirements and improved light technology, we all may be switching to CFLs and LEDs

The Bright Future of Lighting

BY SEAN GROOM

Although still a relatively small slice of the incandescent-dominated lighting market, energy-efficient compact fluorescents (CFLs) and light-emitting diodes (LEDs) have gained traction over the past few years thanks to green-building programs and some progressive local energy codes. They're about to get a real boost.

The Energy Independence and Security Act (EISA) of 2007 soon will limit the number of watts a bulb can consume for a given number of lumens, a measure of light output. The legislation takes effect Jan. 1, 2012, when the luminary equivalent of today's 100w incandescent bulb will be allowed to consume only 72w. (Lower-wattage bulbs also will be affected.)

In other words, incandescent lightbulbs need to become about 28% more efficient to survive. Some industry insiders think they will, but CFLs and LEDs already meet the new requirements. Consequently, the most likely scenario is that incandescent bulbs will be replaced either by CFLs or LEDs, depending on the application.

Compact fluorescents come of age

CFLs were introduced in the early 1990s, but they weren't ready for prime time. Early CFLs produced harsh blue light, hummed, and flickered, making a poor first impression. Today's CFLs, however, produce light in the



Small, powerful, and efficient. Now that they produce white light appropriate for residential settings, LEDs grouped together in a bulb pack enough punch that this 8w LED from Nexxus replaces a 75w PAR30 incandescent bulb.

The color of good light

No matter what type of fixture or bulb you're using, you need to understand light temperature to light your home effectively. There is a spectrum of white light from "warm," which has a yellow-gold hue, to "cool," which has a bluish cast. The hue of the light is described by correlated color temperature (CCT) and is measured in degrees Kelvin, as shown on the scale on the right. Lower numbers are associated with warmer light and higher temperatures with cooler light. For example, an incandescent bulb commonly used in homes has a temperature of about 2700°K, while the daylight fluorescents commonly used in office buildings are about 4100°K.

Along with most finishes in our homes, people look best under warmer light—2700°K to 3000°K. Although cooler light looks harsh on wood, it can be complementary to white and stainless-steel finishes, which are common in more modern homes.

A second measure of light quality is color-rendering index (CRI). When you compare the same color under different light sources, you might notice a color shift. CRI is an attempt to quantify this shift by describing—on a scale of 0 to 100—how well a light source renders color. Good CFLs have a CRI above 80.

If you're in the market for LED lighting, you'll have to see the light for yourself to make an educated purchase. LED standards for CCT or CRI have been voluntary, and some manufacturers' ratings might be called generous.

10,000°K

North light
(blue sky)

9000°K

8000°K

7000°K

Overcast
daylight

6000°K

5000°K

Noon
daylight
Direct sun
Electronic
flashbulbs

4000°K

3000°K

Household
lightbulbs
Early sunrise
Tungsten light
Candlelight

2000°K

1000°K

Degrees Kelvin

COMPACT FLUORESCENTS

**A MULTIDIRECTIONAL LIGHT SOURCE
THAT WORKS WELL FOR AMBIENT, TASK,
AND DECORATIVE LIGHTING**



Replacement bulbs for every application. Often part of the fixture, fluorescent lights need a ballast to operate. These replacement bulbs from Philips, however, have onboard electronic ballasts, which means they can be screwed into existing fixtures for more efficient ambient and decorative lighting. CFLs with pin bases are for fluorescent-only fixtures required by some energy codes.

2700°K range, mimicking the warm, amber-hued light of incandescent bulbs. Also, the old magnetic ballasts have been replaced with quiet electronic ballasts that don't flicker.

CFLs are dramatically more efficient than incandescent lightbulbs, using between 50% and 80% less energy, and they last for about 10,000 hours, nearly 10 times longer than incandescents. They also cost dramatically more. However, replacing one 50¢, 75w incandescent bulb with a \$3.50, 19w CFL saves 563kwh of electricity over the life of the bulb. That comes to about \$75 in savings, depending on the cost of electricity where you live.

On the downside, a typical CFL contains somewhere between 4 mg and 5 mg of mercury. Critics of CFLs highlight the health and environmental hazards of mercury, and special precautions should be taken if the bulbs break in your house. Proponents argue that the mercury in a CFL is far less than the amount of mercury emissions that would be released from a coal-fired power plant if you were using an incandescent bulb. Regardless, when a CFL burns out, it must be recycled so that the mercury doesn't end up polluting the environment. Some retailers of CFLs,



Continuous task lighting. The unique tubes and connectors of Feelux's Slimline allow end-to-end installation, eliminating shadows and dark spots between fixtures in undercabinet and cove lighting.



Dedicated ambient light. Retrofitting an old recessed can with a screw-base CFL could cause premature heat-induced bulb failure. CFL-dedicated recessed cans properly dissipate heat and maximize light output. The can above, from Halo, is remarkably similar to a standard incandescent fixture with the addition of a ballast attached to the junction box. The fixture below, from Lightlier, orients the bulb horizontally and needs just 3½ in. of clearance.



Efficacy at a glance

One measure of lighting efficiency is efficacy. Efficacy is expressed as lumens per watt (lm/w)—the amount of light produced for each unit of electricity consumed. Incandescent lights have efficacies between 10 and 20 lm/w, and fluorescents range from 60 to 100 lm/w. LED products tested last year by the U.S. Department of Energy's Solid-State Lighting program were in the 70 to 80 lm/w range. However, LEDs are expected to surpass fluorescents in the next year and exceed 150 lm/w by 2015. The chart shows representative examples.

including Ikea and The Home Depot, offer CFL recycling. To find other recycling locations, visit www.epa.gov.

Light-emitting diodes are the future

LEDs are a Silicon Valley technology, manufactured in a clean room, just like a computer chip. The chip is usually about 1 mm sq. Current runs through the chip, exciting the electrons and creating light. A small bulblike cover focuses the light. LEDs can't actually produce white light; white light must be created either by combining colors or by using a phosphor coating inside the bulb.

The lighting industry is betting heavily on forging ahead with significant advances in white-light LED technology in the next few years. Many of today's LEDs, however, already perform well when used in the appropriate location.

Manufacturers describe LEDs as cool-operating lamps. While it's true that the lit end of an LED is cool to the touch, the semiconductors do produce heat. And just as computer chips require cooling to perform properly, LEDs need thermal management. The heat sink, usually a number



	Incandescent	CFL	LED
Watts	65	15	12
Lumens	52	675	730
Efficacy (lm/w)	10	45	60

LIGHT-EMITTING DIODES

**A DIRECTIONAL LIGHTING SOURCE
THAT WORKS WELL FOR TASK, ACCENT,
AND DECORATIVE LIGHTING**



Replacement bulbs. Most LED replacement bulbs are directional for accent or task lights, such as the MR16 replacement from Nexus at left. A new generation of LEDs is trying to offer multidirectional ambient light with replacements for fluorescent tubes (from Ilumisys, above) and for the common table lamp (from Philips, center).



Out-of-sight task light. Under cabinets is a natural place to use LEDs because their small size keeps them out of sight and because they're cool to the touch. Also, unlike fluorescents, they don't interfere with radio or TV reception. Available in a range of styles, be sure to select only the amount of light you need so that glare off the counter isn't an issue. The fixture above from Kichler is one example.



of large aluminum fins located near the base of the lamp, is a critical component of an LED.

LEDs are already more efficient than incandescent bulbs, producing approximately 60 to 70 lumens per watt, and manufacturers expect efficiency to surpass that of CFLs soon. Their 50,000-hour average life span translates into 34 years when used four hours a day. There are other advantages to LEDs' solid-state engineering as well: They are immune to vibration, and their performance improves in cold temperatures, making them ideal for outdoor applications.

Cost is currently the biggest drawback to LEDs. A screw-in LED replacement for a recessed light costs about \$120, but remember that LEDs are the lighting equivalent of a computer chip: Just as Intel founder Gordon Moore predicted that chip capacity would double every two years (Moore's Law), Haitz's Law (named for scientist Roland Haitz) states that every decade, LED prices will fall by a factor of 10 while performance will increase by a factor of 20.

Still, a word of caution is appropriate. There are some well-engineered LED bulbs and fixtures on the market, but with so many manufacturers jumping on the bandwagon, there are plenty of LEDs with harsh light and poor switching and dimming response. It's a good idea to evaluate these products carefully before purchasing.

Match the light to the job

Both CFLs and LEDs are available with screw-in bases as replacement bulbs for existing fixtures, but if you are building a new home or remodeling, you might consider fixtures dedicated to one technology or the other. Dedicated fixtures can lengthen the life span of the bulb and maximize its strengths. Both CFLs and LEDs play a role in providing ambient, accent, task, and decorative lighting, the four lay-

ers that create a well-lit room (see "Kitchen Lighting Design," *FHB* #199 and online at FineHomebuilding.com). But CFLs and LEDs aren't necessarily interchangeable. That's largely because CFLs are a multidirectional light source and LEDs are a point source.

Because they are multidirectional and produce large amounts of diffuse light, CFLs work well for ambient, task, and decorative lighting (photos pp. 48-49). They can be used nearly everywhere that incandescent bulbs are used, particularly in table lamps and in shielded sconces, where the fabric or glass adds color to the light. In the bathroom, when they're used behind opaque glass, CFLs do a great job of lighting your face. In kitchens, in laundry rooms, and in offices, CFLs produce bright-enough ambient light to illuminate workspaces.

CFLs are not appropriate everywhere, however. Locations where lights are switched on and off quickly—say an entry hall or a coat closet—are not ideal because short-cycle switching reduces the bulbs' life span. CFLs also need time to attain their full brightness. Also, if you're using a CFL bulb in an outdoor fixture, make sure that it's

Sources The companies listed here had products that impressed us at LightFair, the annual lighting-industry trade show. Visit www.americanlightingassoc.com for a comprehensive list of lighting manufacturers.

American Fluorescent www.americanfluorescent.com • **Ilumisys** www.ilumisys.com • **Kichler** www.kichler.com • **OSRAM Sylvania** www.sylvania.com



Kind of canlike. Although the fixtures look quite common, like the Halo model above, the light module for recessed LED fixtures bears little resemblance to a bulb. With a screw-in adapter like the one shown attached to the Halo module below, LEDs can be retrofit to existing recessed fixtures.



Excellent accent lighting. Small disks (from Kichler, above) and night-lights (from Kichler, below right) provide the low light levels needed for highlighting artwork or providing safe nighttime navigation. Easily concealed, they work in enclosed cabinets without heat buildup and use very little energy to illuminate.



labeled for outside use, which means that the ballast will work in cold temperatures.

Task and accent lighting require focused light

LEDs produce a focused beam of light. Although their relatively small output means they can't throw light as far as some incandescents, there are plenty of circumstances where they work well as task lights. And they're ideal for accent lights because they don't produce UV-light that damages paintings and fabrics. Because LEDs are small and easily produced as pucks or strip lighting, they are ideal for undercabinet illumination or as accent lights hidden in coves or inside cabinets, where small size and low heat output are important.

Glare can be a concern with bright LED fixtures, especially recessed lights. San Francisco Bay Area lighting designer Eric Johnson recommends using a diffuser with recessed cans or, at the very least, recessing the bulb as deep into the fixture as possible.

Lightolier's Calculite is a lensed fixture that uses a diffuser to create white light. Instead of coating the LED bulbs with phosphor, the

phosphor is applied to the diffuser. Under the first approach, variations in the amount of phosphor coating on each diode affect the overall color of the light. When you have multiple downlights in a room, this can result in variations in the light from the different fixtures. It's easier to apply an even, consistent phosphor coating to a glass diffuser, improving the consistency and the color of the light. Placing the reflector above the phosphor layer results in more light output than other methods and less glare, according to the manufacturer.

A unique feature of LEDs is that a single fixture with different types of diodes can create multiple temperatures and colors of light, opening new design possibilities for accent lighting.

One last thing: Both CFLs and LEDs can be tricky to dim. The ballasts and drivers, respectively, must be compatible with the dimmers, and the light may cut out before dimming down all the way. This information is usually indicated on the product. □

Contributing editor Sean Groom lives outside Hartford, Conn. Photos by Dan Thornton, except where noted.

Cooper Lighting (Halo) www.cooperlighting.com • Cree www.cree.com • Feellux www.feellux.com • Journee Lighting www.journeelighting.com • Lightolier www.lightolier.com • Nexxus www.nexxuslighting.com • Maxlite www.maxlite.com • Philips www.philips.com